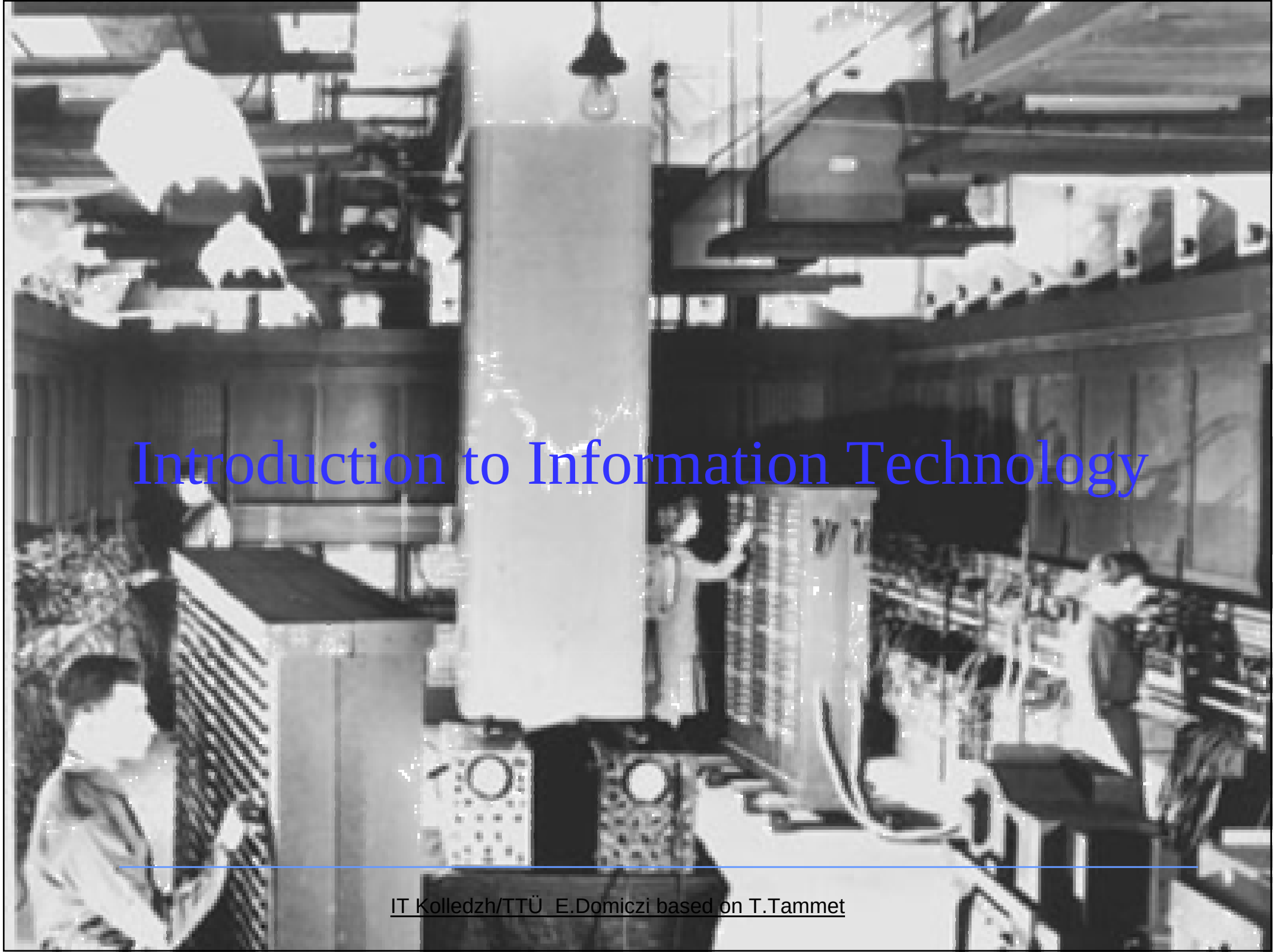


Introduction to Information Technology

Lecture overview

Theory: decade before WWII

- **Turing, Church, Wittgenstein, Shannon**

Genesis of Universal Computers: WWII till 1965

- **First powerful computers in WWII**
- **Zuse, Neumann ja Hopper; first programming languages**
- **Transistors, integrated circuits, memory**
- **First high-level language: Fortran**
- **Birith of Integrated circuits and Processor companyies**
- **Mainframes, mini- and microcomputers**

Turing machine & Lambda-calculus of Church

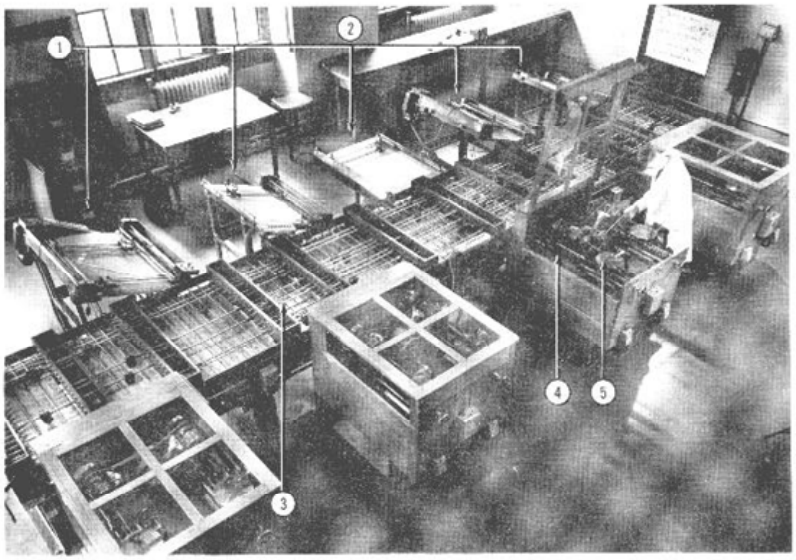
- 1935-1937: article about Turing machine: universality, unsolvability
  - extremely basic symbol-manipulating devices, which can be adapted to simulate the logic of
  - any computer that could possibly be constructed.

- 1936: Alonzo Church (1903-1955) lambda-calculus, Church's thesis.

  universality, unsolvability
  - Lambda calculus
    - the smallest universal programming language.
    - consists of a single transformation rule (variable substitution) and a single function definition scheme.
    - lambda calculus is universal: any computable function can be expressed and evaluated using this formalism.

Vannevar Bush

- **MIT: 1930-1935-1937: Differential Analyzer**
  an analog computer that could solve
  differential equations with as many as 18 independent variables.
- **Last version:**
  - weight 100 tons
  - 2000 vacuum tubes
  - 150 motors
  - thousands of relays



1 Input table
2 Output table
3 Shafts and gears used for interconnection
4 Torque amplifier
5 Integrator disk

FIG. 4. The differential analyzer system, showing integrators, torque amplifiers, and shafting.

Great Logicians: Wittgenstein (1889-1951)

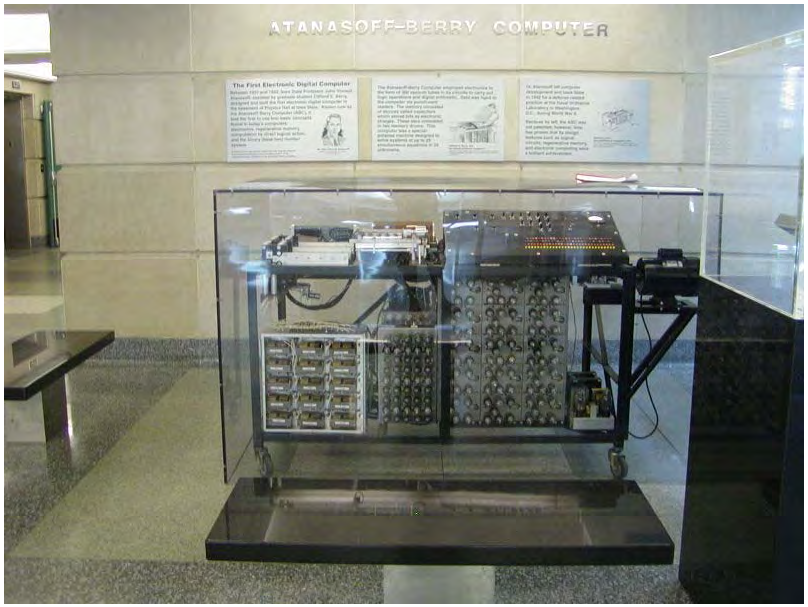
- *L.Wittgenstein, `` **Tractatus Logico-Philosophicus**"*
- Theses of the book:
  - the world consists of independent atomic facts — existing states of affairs — out of which larger facts are built.
  - Language consists of atomic, and then larger-scale propositions that correspond to these facts by sharing the same "logical form."
  - Thought, expressed in language, "pictures" these facts.
  - We can analyse our thoughts and sentences to express ('express' as in *show*, not *say*) their true logical form.
  - Those we cannot so analyse cannot be meaningfully discussed.
  - Philosophy consists of no more than this form of analysis: "*Wovon man nicht sprechen kann, darüber muß man schweigen"* — whereof one cannot speak, thereof one must be silent.

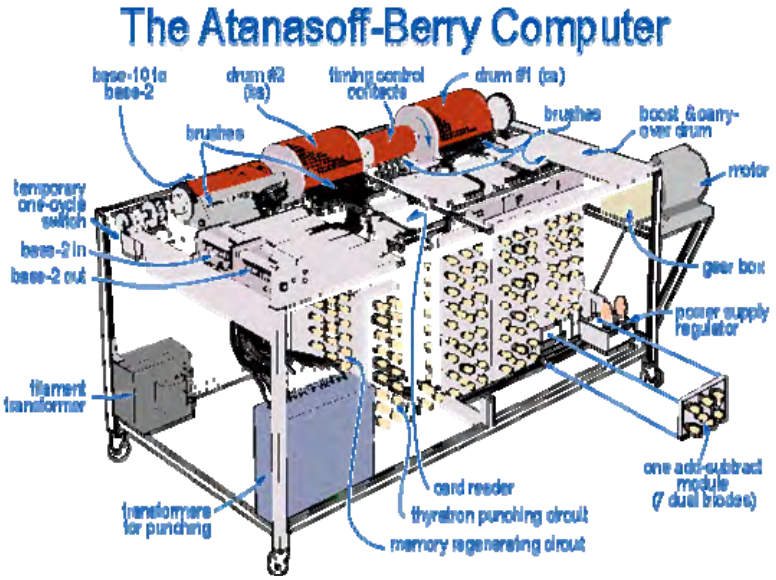
Claude Shannon (1916-2001)

- Offshoot of the Differential Analyzer work at MIT was the **birth of digital circuit design theory** by one of Bush's graduate students, Claude Shannon.
- MIT, 1938, Shannon's Master's Thesis
  (A Symbolic Analysis of Relay and Switching Circuits)
  ""possibly the most important, and also the most famous, master's thesis of the century" ":
  - proved that Boolean algebra and binary arithmetic could be used **to simplify** the arrangement of the electromechanical relays then used in telephone routing switches
  - then turned the concept upside down and also proved that it should be possible to **use arrangements of relays to solve Boolean algebra problems**

Atanasoff's computer

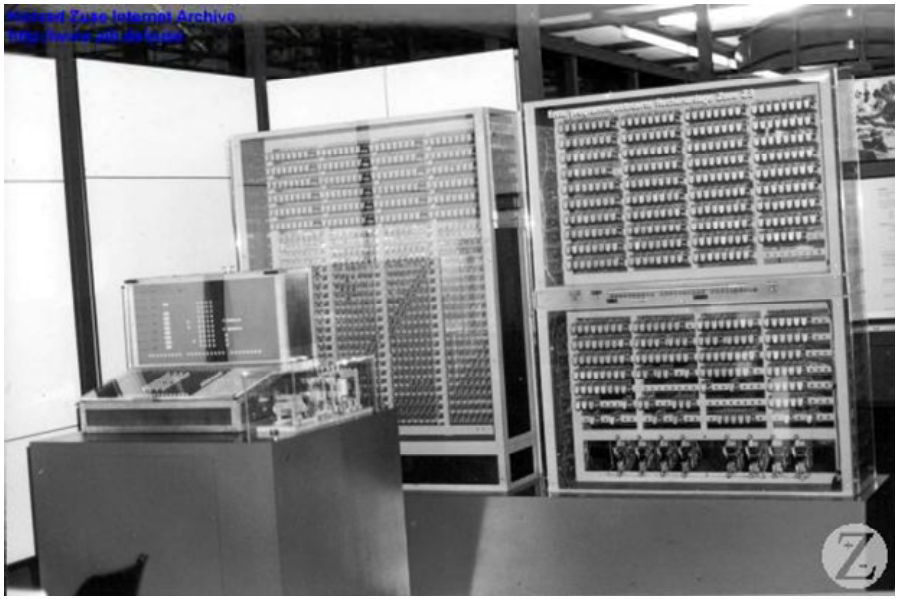
- John Vincent Atanasoff (1903-1955)
- The Atanasoff-Berry Computer (ABC) was the first electronic digital computing device.
- The machine, conceived in 1937, was capable of solving up to 29 simultaneous linear equations and was successfully tested, though its input/output mechanism was still unreliable in 1942
- It was not a Turing complete computer
  (Turing complete: computational power capable of emulating a simplified model of a programmable computer known as the universal Turing machine)





Zuse's computer: Z3

- Konrad Zuse (1910-1995)
- first functional tape-stored-program-controlled computer, the Z3
  (in 1998 the Z3 was proven to be Turing-complete)
- first high-level programming language, the Plankalkül
- Z4, which became the first commercial computer (1946-1950)



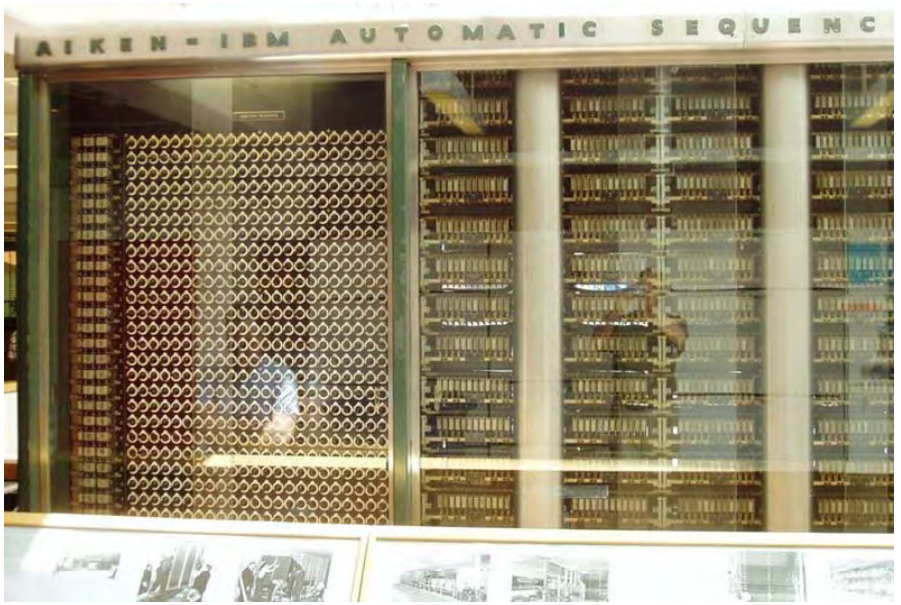
Colossus vs Geheimfernschreiber

- The Colossus machines were early computing devices used by British codebreakers to read encrypted German messages during World War II.
  - not Turing-complete
    even though Alan Turing on whose research this definition was based,
    worked at Bletchley Park where Colossus was put into operation
- Geheimfernschreiber ("secret teleprinter”), aka
  T52 and
  Schlüsselfernschreibmaschine (SFM),
  codenamed Sturgeon by British cryptanalysts
  - a World War II German teleprinter cipher machine.

Mark I

- Howard Aiken (1900-1973)
  - devised the computer
  - At the dedication ceremony, Aiken failed to mention the involvement of IBM
    IBM was not pleased with this, and parted ways with Aiken.
- IBM's electric digital computer (Harvard) MARK I
  aka ASCC (Automatic Sequence Controlled Calculator)
  aka Aiken-IBM Automatic Sequence Controlled Calculator Mark I

  1939-1944
  - 750.000 components, 5 tons
  - could store 72 numbers, each 23 decimal digits long.
  - 3 additions or subtractions in a second.
  - multiplication took 6 seconds, a
  - division took 15.3 seconds
  - logarithm or a trigonometric function took over one minute.
  - read instructions from a punched paper tape
  - A loop was accomplished by joining the end of the paper tape containing the program back to the beginning of the tape (literally creating a loop).
- Mark IV all-electronic



1945

- Konrad Zuse **began work on** Plankalkül **(plan Calculus). The first algorithmic programming language, with an aim of creating the theoretical preconditions for the formulation of problems of a general nature.**

- John von Neumann **wrote "First Draft of a Report on the EDVAC."**

- Grace Hopper **recorded the first actual computer "bug."**

1946

- **In February, the public got its first glimpse of the ENIAC, a machine built by John Mauchly and J. Presper Eckert that improved by 1,000 times on the speed of its contemporaries.**

START OF PROJECT: 1943

COMPLETED: 1946

PROGRAMMED: plug board and switches

SPEED: 5,000 operations per second

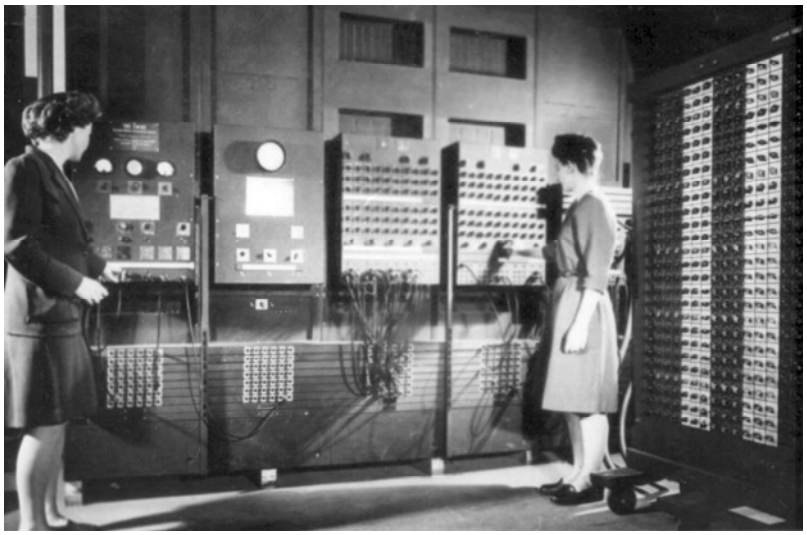
INPUT/OUTPUT: cards, lights, switches, plugs

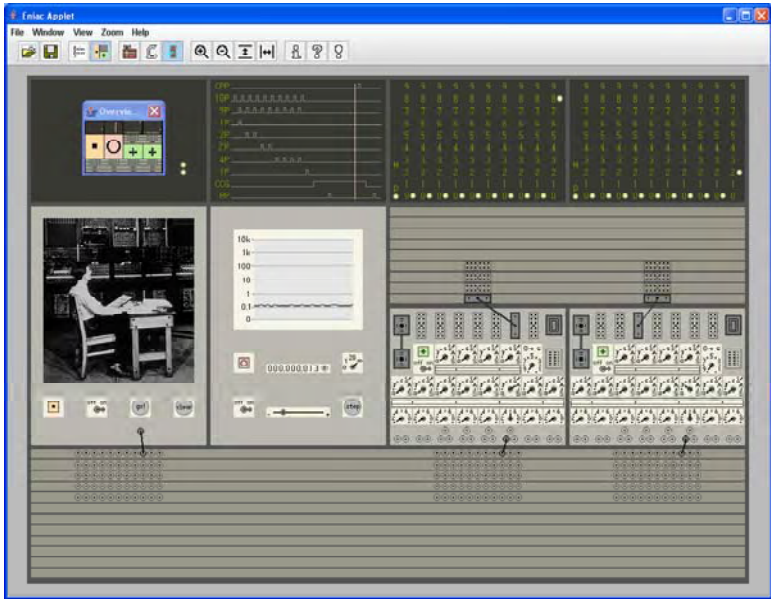
FLOOR SPACE: 1,000 square feet

PROJECT LEADERS: John Mauchly and J. Presper Eckert.

Eniac

- ENIAC, short for Electronic Numerical Integrator and Computer
- was the first
  (there was a controversy about this)
  - large-scale,
  - electronic,
  - digital computer
  - reprogrammable
    - the first problems run on the ENIAC were related to the design of the hydrogen bomb.
- Eniac Java Simulation
  http://www.zib.de/zuse/Inhalt/Programme/Eniac/eniac.html





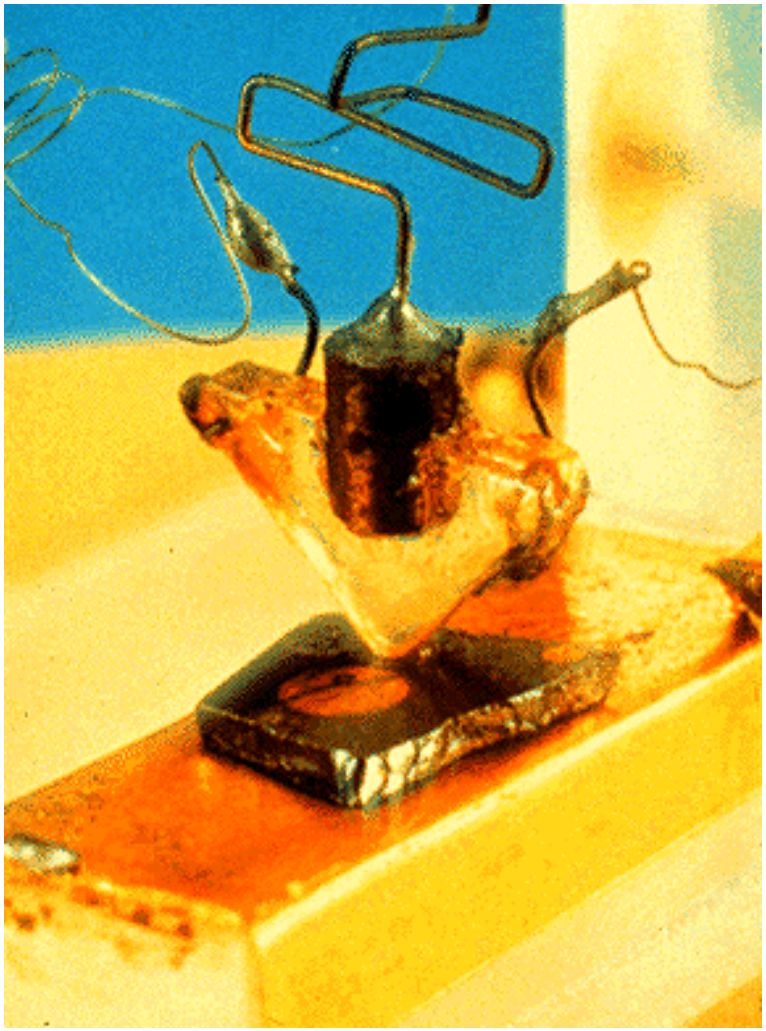
Comparison of early computers

Defining characteristics of five first operative digital computers

Computer	Nation	Year	Digital	Binary	Electronic	Programmable	Turing complete
Atanasoff-Berry Computer	USA	1937–42	Yes	Yes	Yes	No	No
Zuse Z3	Germany	1941	Yes	Yes	No	Fully, by paper tape	Yes
Colossus computer	UK	1944	Yes	Yes	Yes	Partially, by rewiring	No
Harvard Mark I/IBM ASCC	USA	1944	Yes	No	No	By paper tape	Yes
ENIAC	USA	1946	Yes	No	Yes	Partially, by rewiring	Yes

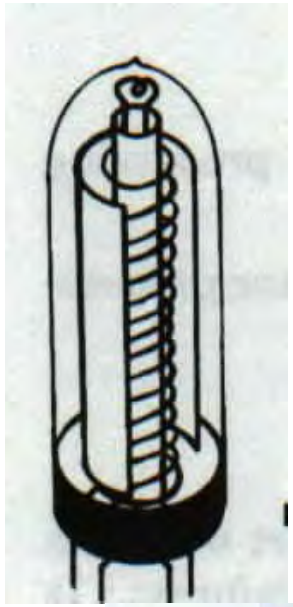
1947

- **Three scientists at** Bell Telephone Laboratories**, William Shockley, Walter Brattain, and John Bardeen demonstrate their new invention of the point-contact transistor amplifier.**



Review: operating principles of vacuum tubes

- Vacuum Tube (1906, Lee Deforest)
- Three elements device used as electronic switch and amplifier: two electrodes separated by a grid in a vacuum glass enclosure.

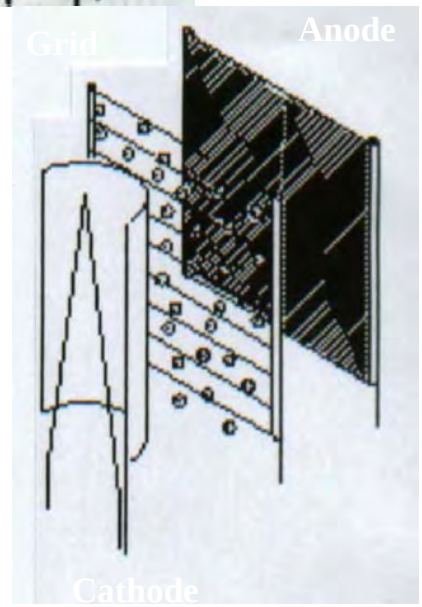


- Principle

Cathode - emits electrons;

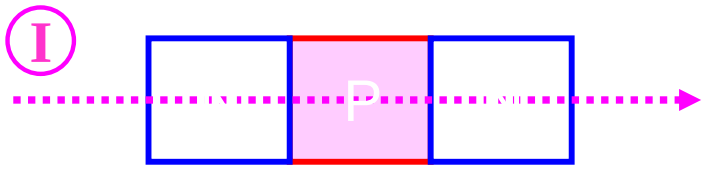
Plate (anode) - receives the electrons;

Grid - with negative bias voltage repels some of the electrons and prevents them from reaching the plate, resulting in less current flow. A changing negative charge on the grid modulates the plate current.



Transistor's working principle

- **Transistor**
- **Three elements solid-state device for amplifying, controlling electrical signals.**

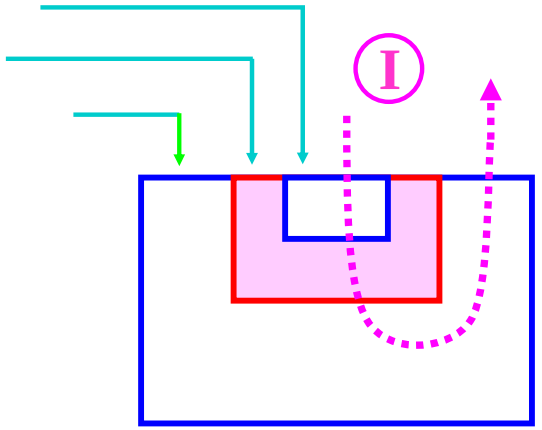


- **Principle**

Current flows from emitter through base into collector;

***Switching* - Base current on, collector current flows - Switching;**

***Amplification* - Base current regulates large amount of collector current.**



1948

- **John Bardeen, Walter Brattain, and William Schockley of Bell Labs file for** a patent on the first transistor**.**

- The Mathematical Theory of Communication**. Claude** Shannon**'s "The Mathematical Theory of Communication" showed engineers how to code data so they could check for accuracy after transmission between computers. Shannon identified the bit as the fundamental unit of data and, coincidentally, the basic unit of computation.**

- Norbert Wiener **published "**Cybernetics**," a major influence on later research into artificial intelligence. He drew on his World War II experiments with anti-aircraft systems that anticipated the course of enemy planes by interpreting radar images.**

1949

- Maurice Wilkes **assembled the** EDSAC**, the first practical** stored-program computer**, at Cambridge University. His ideas grew out of the Moore School lectures he had attended three years earlier. For programming the EDSAC, Wilkes established a library of short programs called subroutines stored on punched paper tapes.**

TECHNOLOGY: vacuum tubes

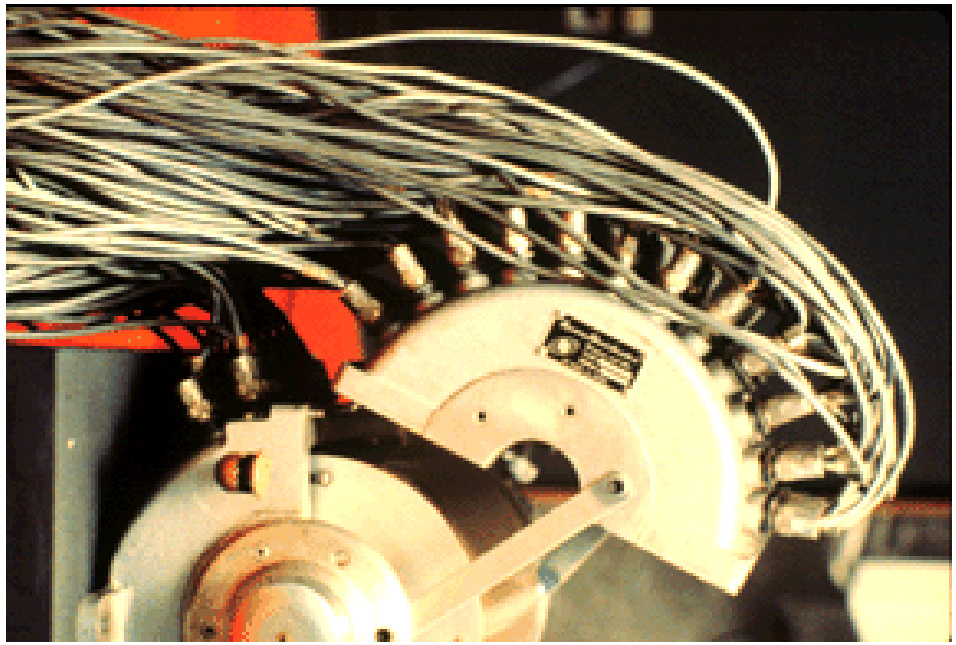
MEMORY: 1K words, 17 bits, mercury delay line

SPEED: 714 operations per second

1950

- **Engineering Research Associates of Minneapolis built the** ERA 1101, the first commercially produced computer**; the company's first customer was the U.S. Navy.**

It held 1 million bits on its magnetic drum**, the earliest magnetic storage devices. Drums registered information as magnetic pulses in tracks around a metal cylinder. Read/write heads both recorded and recovered the data. Drums eventually stored as many as 4,000 words and retrieved any one of them in as little as five-thousandths of a second.**



1951

- **The** UNIVAC I **delivered to the U.S. Census Bureau was the first** commercial computer to attract widespread public attention**. Although manufactured by Remington Rand, the machine often was mistakenly referred to as the "IBM UNIVAC." Remington Rand eventually sold 46 machines at more than $1 million each.**

SPEED: 1,905 operations per second

INPUT/OUTPUT: magnetic tape, unityper, printer

MEMORY SIZE: 1,000 12-digit words in delay lines

MEMORY TYPE: delay lines, magnetic tape

TECHNOLOGY: serial vacuum tubes, delay lines, magnetic tape

FLOOR SPACE: 943 cubic feet

COST: F.O.B. factory $750,000 plus

Early AI programs: checkers, chess (in Britain)

- **Strachey wrote a** checkers program **for the Ferranti Mark I at Manchester (with Turing's encouragement and utilising the latter's recently completed Programmers' Handbook for the Ferranti computer). By the summer of 1952 this program could, Strachey reported, "play a complete game of Draughts at a reasonable speed".**
- **Prinz's** chess program**, also written for the Ferranti Mark I, first ran in November 1951. It was for solving simple problems of the mate-in-two variety. The program would examine every possible move until a solution was found. On average several thousand moves had to be examined in the course of solving a problem, and the program was considerably slower than a human player.**
- **Turing started to program his** Turochamp chess-player **on the Ferranti Mark I but never completed the task. Unlike Prinz's program, the Turochamp could play a complete game and operated not by exhaustive search but under the guidance of rule-of-thumb principles devised by Turing.**

Early AI programs: checkers (in USA)

- **The first AI program to run in the U.S. was also a checkers program, written in 1952 by** Arthur Samuel **of IBM for the IBM 701.**
- **Samuel took over the essentials of Strachey's program (which Strachey had publicised at a computing conference in Canada in 1952) and over a period of years considerably extended it.**
- **In 1955 he added features that enabled the program to learn from experience, and therefore improve its play. Samuel included mechanisms for both rote learning and generalisation. The program soon learned enough to outplay its creator. Successive enhancements that Samuel made to the learning apparatus eventually led to the program winning a game against a former Connecticut checkers champion in 1962 (who immediately turned the tables and beat the program in six games straight).**

1952

- **Heinz Nixdorf founded** Nixdorf Computer Corp**. in Germany. It remained an independent corporation until merging with Siemens in 1990.**

- **A complaint is filed against IBM, alleging** monopolistic practices **in its computer business, in violation of the Sherman Act.**

- **G. W. Dummer, a radar expert from Britain's Royal Radar Establishment presents a paper proposing that** a solid block of materials be used to connect electronic components**, with no connecting wires.**

1953

- IBM **shipped its first** electronic computer**, the 701.**
- **Speedcoding: John Backus.**

1954

- Texas Instruments **announces the start of** commercial production on silicon transistors**. [110]**

- **Herbert Simon and Allen Newell unveiled** Logic Theorist software **that supplied rules of reasoning and proved symbolic logic theorems.**

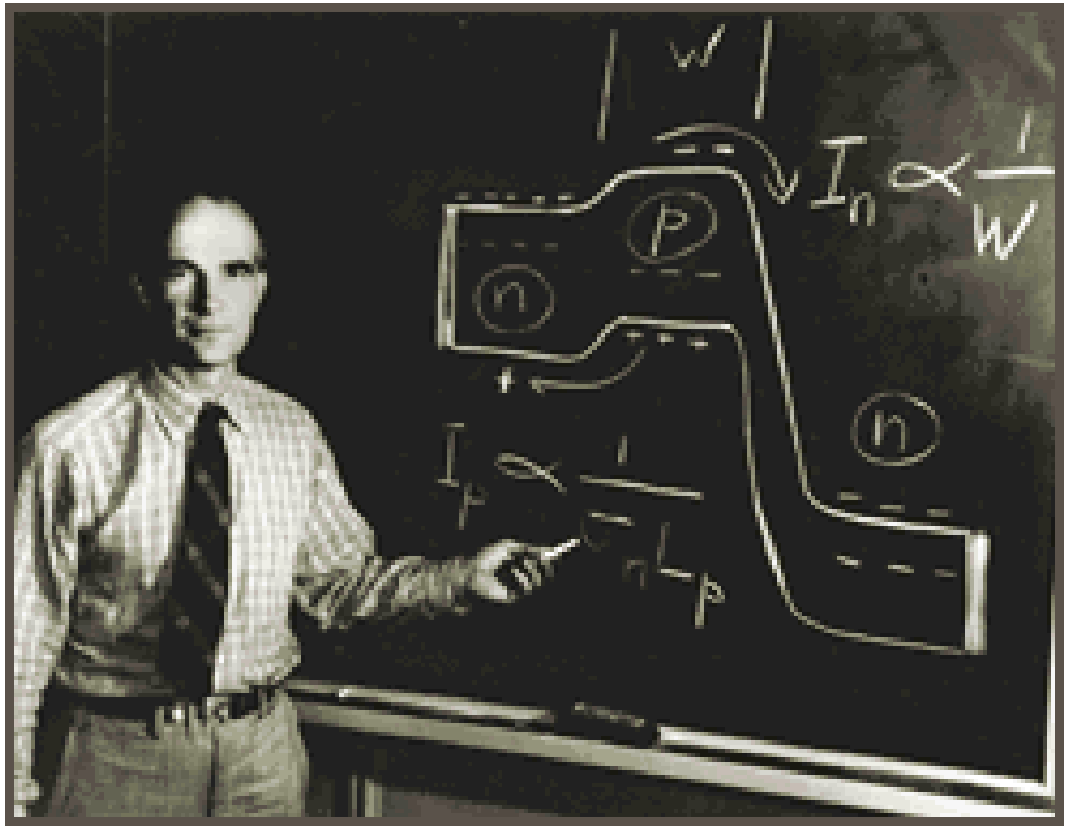
- **The Logic Theorist, as the program became known, was the major exhibit at a conference organised in 1956 at Dartmouth College, New Hampshire, by John McCarthy, who subsequently became one of the most influential figures in AI.**

- **Newell, Simon and Shaw went on to construct the General Problem Solver, or GPS. The first version of GPS ran in 1957 and work continued on the project for about a decade. GPS could solve an impressive variety of puzzles, for example the "missionaries and cannibals" problem.**

1955

- **William Shockley founds** Shockley Semiconductor **in Palo Alto, California**

However, the venture did not go well, partly because of Shockley's managerial style, and partly because he diverted resources away from transistor technology and into the creation of a 4-layer switching diode, a device which he had conceived whilst still at Bell.



1956

- **A U.S. District Court makes a** final judgement on the complaint against IBM **filed in January 1952 regarding monopolistic practices. A "consent decree" is signed by IBM, placing limitations on how IBM conducts business with respect to "electronic data processing machines".**

- IBM **develops** the first hard disk**, the RAMAC 305, with 50 two-foot diameter platters. Total capacity is** 5 MB**. (350 Disk Storage Unit)**

- The first transistorized computer **is completed, the TX-O (Transistorized Experimental computer), at the Massachusetts Institute of Technology.**

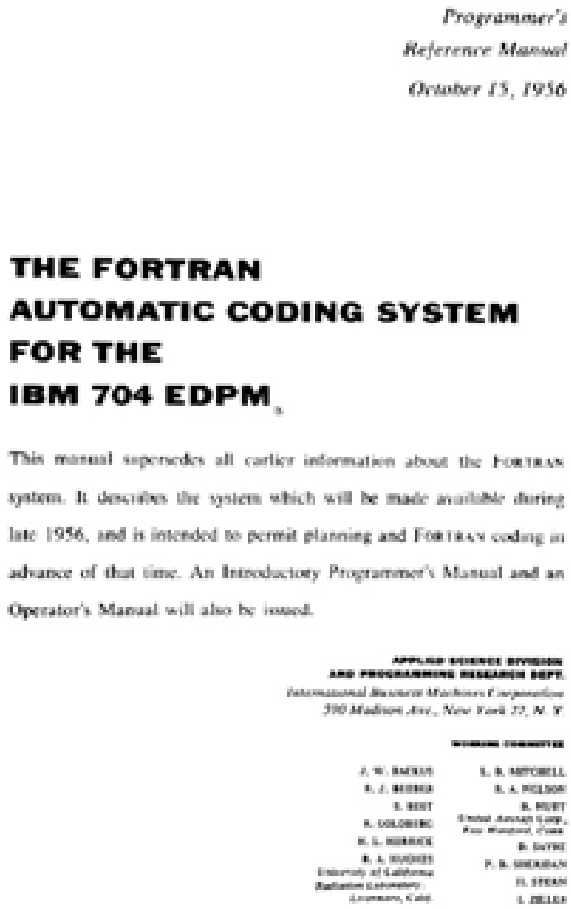
The Nobel Prize in physics **is awarded to John Bardeen, Walter Brattain, and William Shockley for their** work on the transistor**.**

1957…

- **A new language,** FORTRAN **(short for formula translator), enabled a computer to perform a repetitive task from a single set of instructions by using loops.**

The first commercial FORTRAN program ran at Westinghouse, producing a missing comma diagnostic.

A successful attempt followed.



Programmer's
Reference Manual
October 15, 1956

THE FORTRAN
AUTOMATIC CODING SYSTEM
FOR THE
IBM 704 EDPM

This manual supersedes all earlier information about the FORTRAN system. It describes the system which will be made available during late 1956, and is intended to permit planning and FORTRAN coding in advance of that time. An Introductory Programmer's Manual and an Operator's Manual will also be issued.

… 1957

- **A group of eight engineers leaves Shockley Semiconductor to form** Fairchild Semiconductors**.**

- **Kenneth Olsen founds**

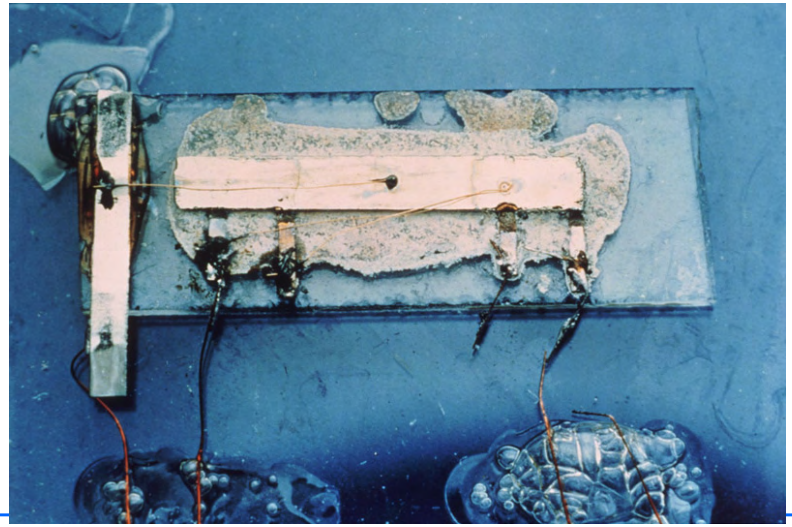
Digital Equipment Corporation**.**

Left to right: Moore, Roberts, Kliner, Noyce, Ginrich, Blank, Hoerni, Last

1958

- **At** Texas Instruments**,** Jack St. Clair Kilby **comes up with** the idea **of creating a monolithic device (**integrated circuit**) on a single piece of silicon.**
- **Later (in 2000) Kilby receives Nobel prize in physics**

- Jack Kilby completes building the first integrated circuit**, containing five components on a piece of germanium half an inch long and thinner than a toothpick.**



1958

- SAGE **-- Semi-Automatic Ground Environment -- linked hundreds of radar stations in the United States and Canada in** the first large-scale computer communications network.

1959

- Fairchild Semiconductor files a patent application for the planar process for manufacturing transistors**. The process makes commercial production of transistors possible and leads to Fairchild's introduction, in two years, of the first integrated circuit.**

- **Texas Instruments** announces the discovery of the integrated circuit**.**

- **At Fairchild Semiconductor,** Robert Noyce constructs an integrated circuit **with components connected by aluminum lines on a silicon-oxide surface layer on a plane of silicon.**

- **Fairchild Semiconductor announces** their independent discovery **of the integrated circuit.**

1960

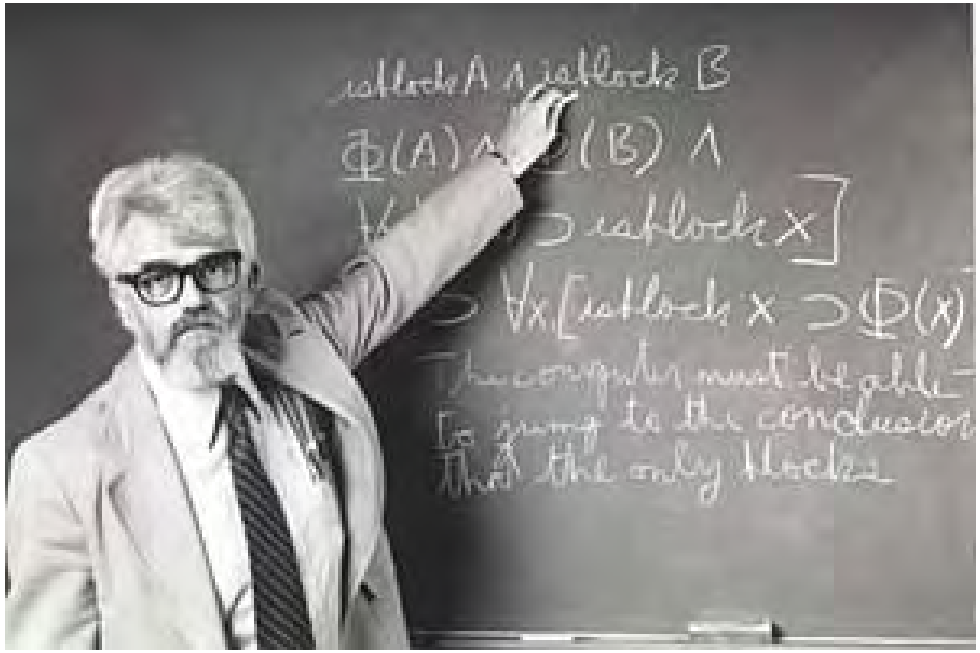
- IBM **develops the first** automatic mass-production facility **for transistors, in New York.**

- **AT&T designed its Dataphone,** the first commercial modem**, specifically for converting digital computer data to analog signals for transmission across its long distance network**

1960

- **A team drawn from several computer manufacturers and the Pentagon developed** COBOL**, Common Business Oriented Language. Project leader: Grace Hopper.**

- LISP **made its debut as the first computer language designed for writing artificial intelligence programs. Inventor: John McCarthy.**



1961

- **Fairchild Semiconductor releases** the first commercial integrated circuit**.**

- **According to Datamation magazine,** IBM had an 81.2-percent share **of the computer market in 1961, the year in which it introduced the 1400 Series.**

1962

- Teletype **ships its Model 33 keyboard and punched-tape terminal, used for input and output on many early microcomputers.**

- **Ivan Sutherland creates a graphics system called** Sketchpad**.**

1963

- Douglas Engelbart **receives a patent on the** mouse **pointing device for computers.**

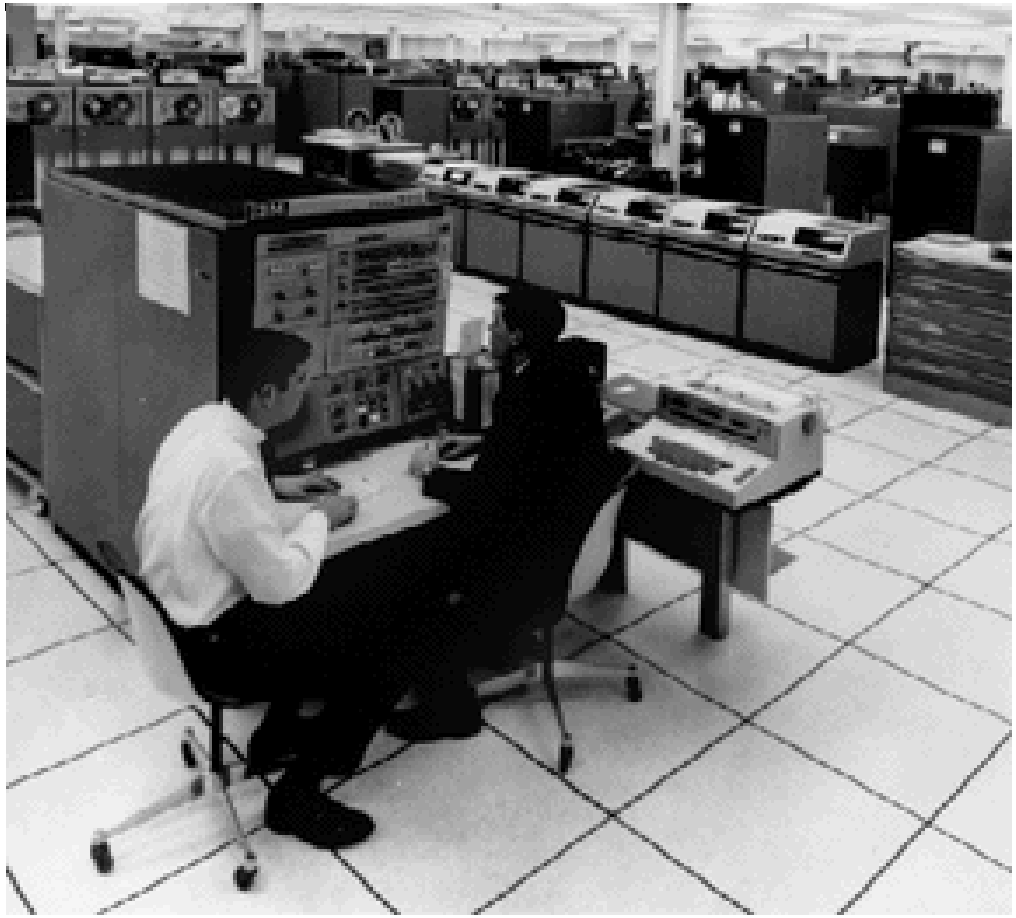
- ASCII **-- American Standard Code for Information Interchange -- permitted machines from different manufacturers to exchange data**

- **Digital Equipment** sells its first minicomputer**, to Atomic Energy of Canada.**

1964 …

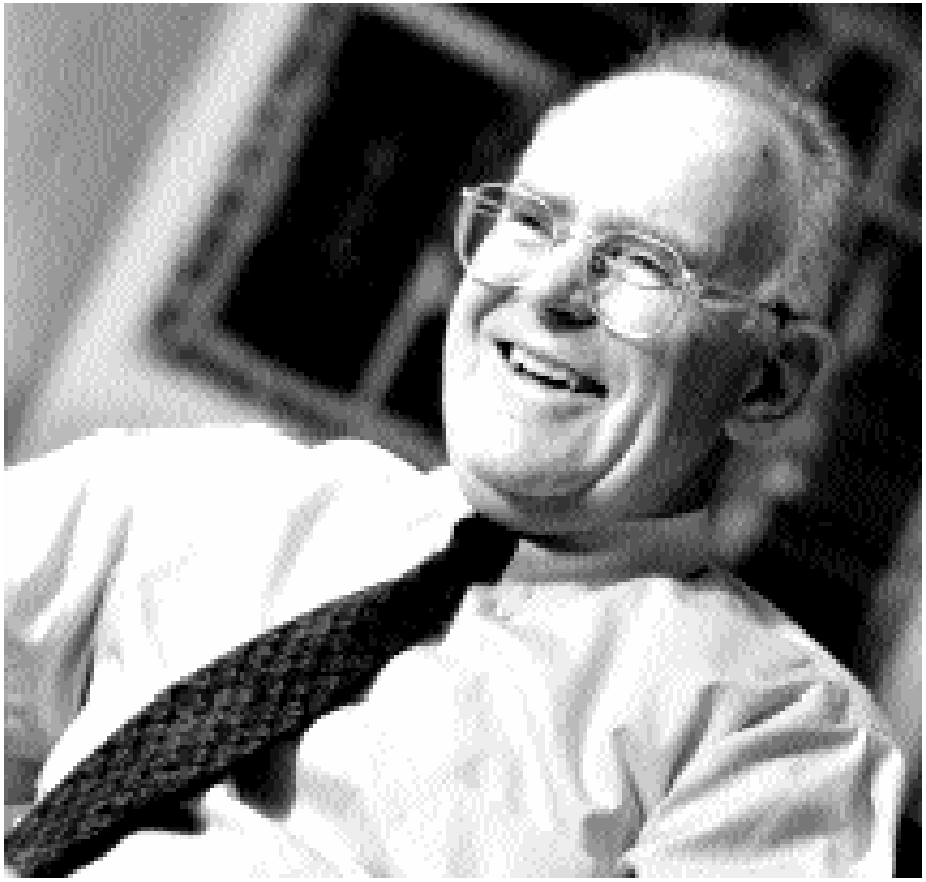
- **Ian Sharp and others found I.P.** Sharp Associates**, in Canada.**

- **IBM announced** System/360**, a family of six mutually compatible computers and 40 peripherals that could work together**



…1964

- **Gordon Moore suggests that integrated circuits would double in complexity every year. This later becomes known as** Moore's Law**.**



Gordon E. Moore

1929 -

1950 B.S. in Chemistry

1954 Ph.D. from Cal Tech

1954-1957 *Shockley Semiconductor*

1957 Co-Founder of *Fairchild Semiconductors*

1965 Moore's Law

1968 Moore, Noyce and Grove left *Fairchild Semiconductors* and founded ***Intel Corp.***

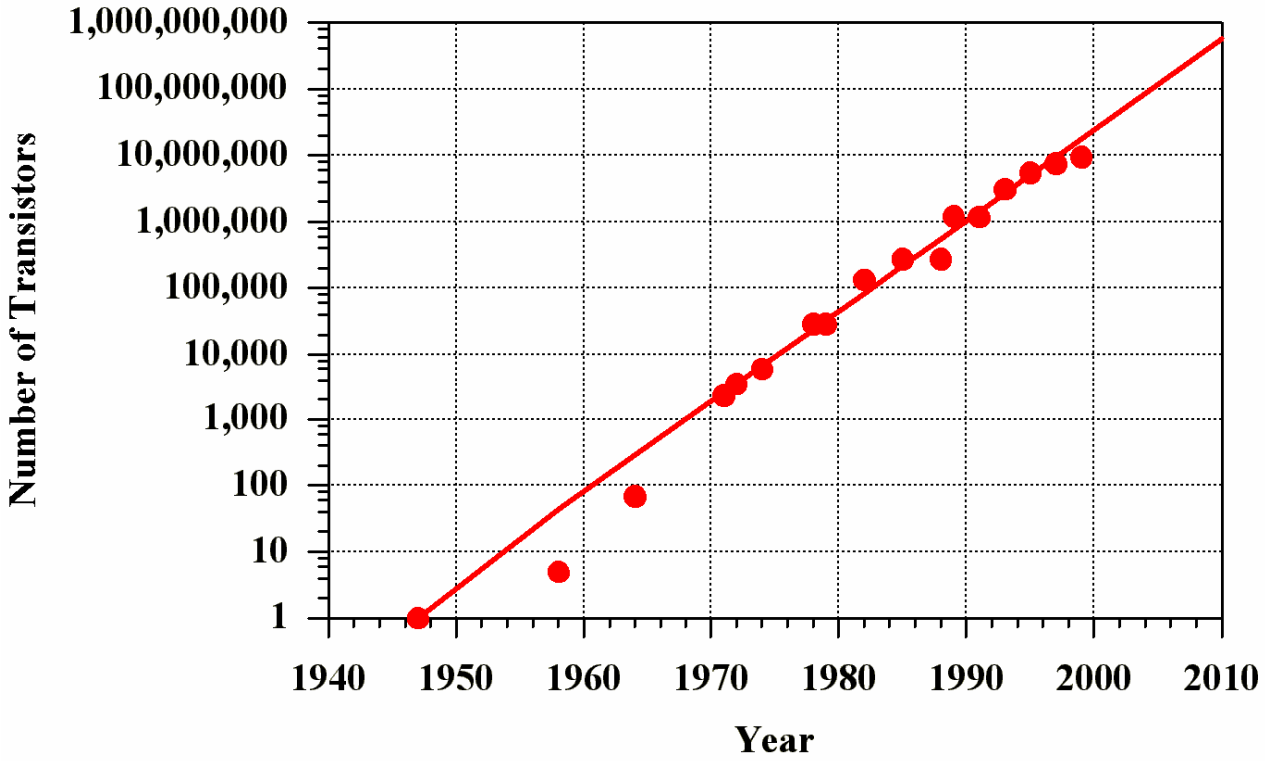
1968-1997 Intel's president

Moore's law

Moore's Law (1965)

Circuits per chip

= 2 (year-1975) / 1.5



"Each new chip contains roughly twice as much capacity as its predecessor, and is released within 18-24 months of the previous chip."

…1964

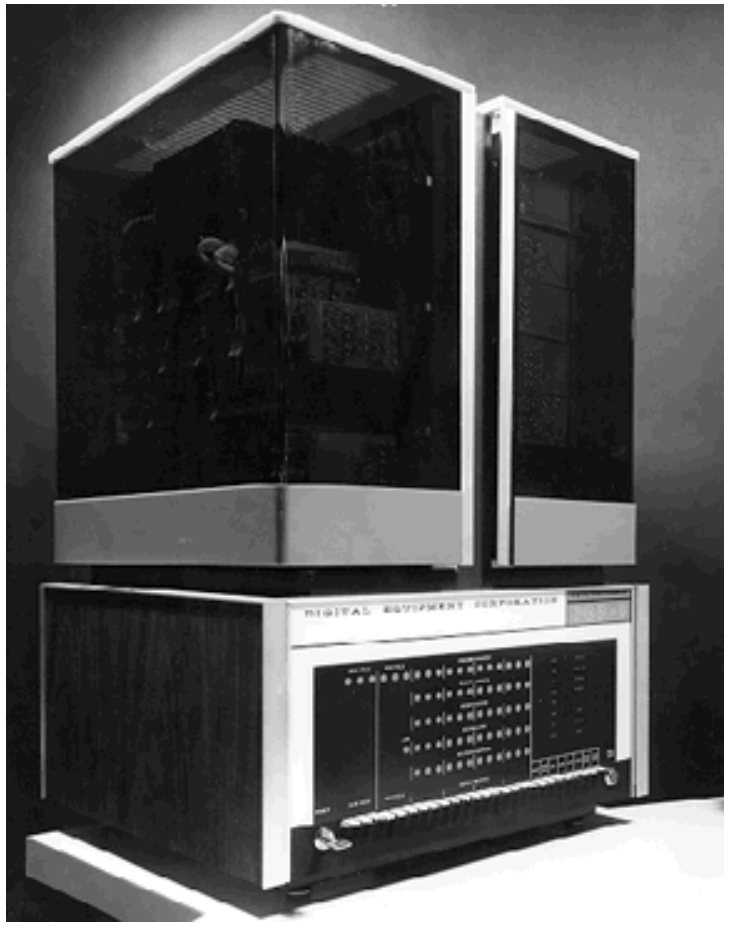
- CDC's 6600 supercomputer**, designed by** Seymour Cray**, performed up to 3 million instructions per second -- a processing speed three times faster than that of its closest competitor, the IBM Stretch.**

- **John Kemeny and Thomas Kurtz develop the** BASIC **programming language at Dartmouth College. BASIC is an acronym for Beginners All-purpose Symbolic Instruction Code.**

- Texas Instruments **receives a** patent on the integrated circuit**.**

1965

- **Digital Equipment Corp. introduced the** PDP-8**, the first commercially** successful minicomputer**. The PDP-8 sold for $18,000, one-fifth the price of a small IBM 360 mainframe. The speed, small size, and reasonable cost enabled the PDP-8 to go into thousands of manufacturing plants, small businesses, and scientific laboratories.**



1966

- **Steven Gray founds the** Amateur Computer Society**, and begins publishing the ACS Newsletter. Some consider this to be the birth-date of personal computing.**

- International Research Corp**. is incorporated by Wayne Pickette as a one man, California corporation. Purpose, to research educational resources and technological improvements for education**

1967…

- **The first Consumer Electronics Show is held in New York City.**

- **International Research applies for a patent for a method of constructing double sided magnetic tape utilizing a MU-Metal Foil Inter layer. Legal problems with a professor at the University of North Carolina, cause Wayne Pickette to drop the quest for that patent. Wayne Pickette makes acquaintence with the famous entrepreneur Arthur Rock of San Francisco.**

- **IBM builds the** first floppy disk**.**

…1967

- **Seymour Papert designed** LOGO **as a computer language for children.**

1968…

- Edsger Dijkstra's "GO TO considered harmful" **letter, published in Communications of the ACM, fired the first salvo in the** structured programming **wars.**

- **International Research Corp., in San Martin, California, develops the architecture for a computer-on-a-chip modeled on an enhanced PDP-8/S concept.**

- **Wayne Pickette proposes to Fairchild Semiconductor that they develop his design for a computer-on-a-chip. Fairchild turns down his offer.**

- **Wayne Pickette works for IBM during the Summer as a Logic Designer on Project Winchester, the enclosed flying-head disk drive. Wayne Pickette subsequently declines the IBM offer to finance his education.**

…1968

- **Robert Noyce and Gordon Moore leave Fairchild Semiconductors.**
- **Robert Noyce and Gordon Moore found** Intel Corporation**.**
- **Ed Roberts and Forest Mims found Micro Instrumentation Telemetry Systems (**MITS**).**
- **IBM scientist John Cocke and others complete a prototype scientific computer called the ACS. It incorporates some** RISC concepts**, but the project is later canceled due to the instruction set not being compatible with that of IBM's System/360 computers.**

…1968

- Douglas C. Engelbart**, of the Stanford Research Institute, demonstrates his** system of keyboard, keypad, mouse, and windows **at the Joint Computer Conference in San Francisco's Civic Center. He demonstrates use of** a word processor, a hypertext system, and remote collaborative work with colleagues**.**

1969

- **AT&T Bell Laboratories programmers Kenneth Thompson and Dennis Ritchie developed the** UNIX **operating system on a spare DEC minicomputer.**
- Advanced Micro Devices **Incorporated is founded. [141]**
- **Intel's Marcian (Ted) Hoff designs an integrated circuit chip that could receive instructions, and perform simple functions on data. The design becomes the** 4004 microprocessor**.**
- **Intel announces a** 1 KB RAM chip**, which has a significantly larger capacity than any previously produced memory chip.**
- Bill Gates and Paul Allen**, calling themselves the "Lakeside Programming Group" sign an agreement with Computer Center Corporation to report bugs in PDP-10 software, in exchange for computer time.**

1969

- Microsystems International **is incorporated** to manufacture microchips**. The company was formerly the Advanced Devices Centre of Northern Electric and Manufacturing Company (Canada).**
- **Jerry Sanders and seven others leave Fairchild Semiconductor to form** Advanced Micro Devices**.**
- **Gary Starkweather, at Xerox's research facility in Webster, New York, demonstrates using a laser beam with the xerography process to create** a laser printer**.**
- **Digital Equipment hires David Ahl as a marketing consultant.**